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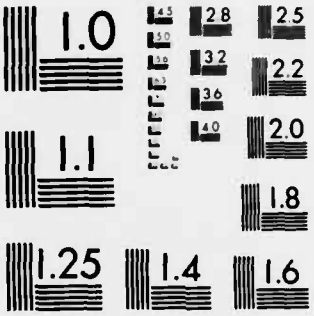

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TELECOMMUNICATIONS CAPABILITIES FOR THE U.S. DEFENSE MAPPING AGENCY'S AUTOMATED NOTICE TO MARINERS SYSTEM

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ABSTRACT

The Defense Mapping Agency (DMA) has developed capabilities to telecommunicate Automated Notice to Mariners to remote users including merchant ships at sea that have INMARSAT terminals. A Research and Development feasibility study of civilian and military telecommunication networks indicated that a large number of ANMS users are linked to the domestic telephone network, TWX, Telex, foreign telephone networks (CCITT modems), and AUTODIN I. DMA initiated a pilot program to link the ANMS Prime 400 computer to these networks enabling users with appropriate modems and terminals to receive ANMS by remote interactive query. The TWX, Telex, domestic, and foreign phone network interfaces have been implemented and tested. The AUTODIN I interface is under development and new capabilities such as computer to computer downline loading, transmission of graphics and ties to value-added networks are planned.

INTRODUCTION

The United States Defense Mapping Agency (DMA) designed the Automated Notice to Mariners System (ANMS) with hardware and software capabilities to utilize modern communications systems. In 1980, DMA initiated a research project with the U.S. Army Engineer Topographic Laboratories for the purpose of implementing those capabilities. The first phase of the effort was a feasibility study designed to identify candidate telecommunication systems, mainly through analysis of systems specifications versus ANMS transmission requirements, that could link the ANMS to users in the field. The study concluded that several individual telecommunication systems could serve certain parts of the ANMS customer population, but no one system served all users. Systems including Telex, TWX, U.S. public telephone system, AUTOVON, AUTODIN I, and certain public data networks, such as Telenet or Tymnet, can be used to transmit ANMS data. Ships at sea can be reached by Telex or through the public telephone system with both terrestrial systems relayed to ships via the Maritime Satellite (MARISAT) system, now the International Maritime Satellite (INMARSAT)

System. U.S. Naval vessels can be reached through an AUTODIN I link to the Fleet Satellite Communications (FLTSATCOM) System or, for some Navy ships, through INMARSAT.

Since certain systems were available, DMA and ETL developed plans to initiate a pilot program of basic operating capabilities for electronic distribution of ANMS. The pilot effort began in February 1981 and consisted of installation, trouble shooting, and testing of interface equipments for the above named systems.

The goal of the ANMS telecommunications pilot program was to make the ANMS data available to as many users as possible using existing networks and communications equipment, i.e., equipment that is owned and operated by the user. The concept was to introduce the ANMS remote query capability to the user at little or no expense to him for equipment or network links. The reason for providing the pilot transmission capability was to demonstrate to potential users a more cost-effective, faster, and more sophisticated means of receiving ANMS data. The demonstrations also proved, from an engineering view, that telecommunications links can be successfully implemented over networks that were primarily designed for voice and message traffic.

THE AUTOMATED NOTICE TO MARINERS SYSTEM DESCRIPTION

The Prime 400 Computer System

The ANMS consists of hardware and software for updating records, processing information, printing the Notice to Mariners publication, and providing remote telecommunications access to the resultant data base for users in the field. The entire system is shown in Figure 1. The Prime 400 computer provides the central processing capability for the system. It receives input from IMLAC "intelligent" terminals, processes the information, provides a tape for production of a publication, and provides an interactive query capability for remote customers. An Asychronous Multiple Link Controller (AMLC) interfaces all communications with remote users to the central processing unit (CPU) in the computer. The Prime can communicate in ASCII through the AMLC with up to 63 concurrent external devices. The AMLC is capable of interfacing with remote equipment including modems, printers, cathode ray tube terminals, and teletypewriter terminals. The physical characteristics of the computer-to-data communications equipment interface and the meaning of each signal line are defined by the EIA RS-232C standard.

Remote Query Customers

The ANMS, to be most effective, must be able to interface with the users available communications systems at their location when the navigational data is needed. Recipients of the weekly Notice to Mariners are civil and military. Among those receiving the Notice to Mariners are institutions and private organizations who have a need for reference material only and no identifiable real-time requirement. The customers who have a more immediate need

THE AUTOMATED NOTICE-TO-MARINERS TELECOMMUNICATIONS LINKS

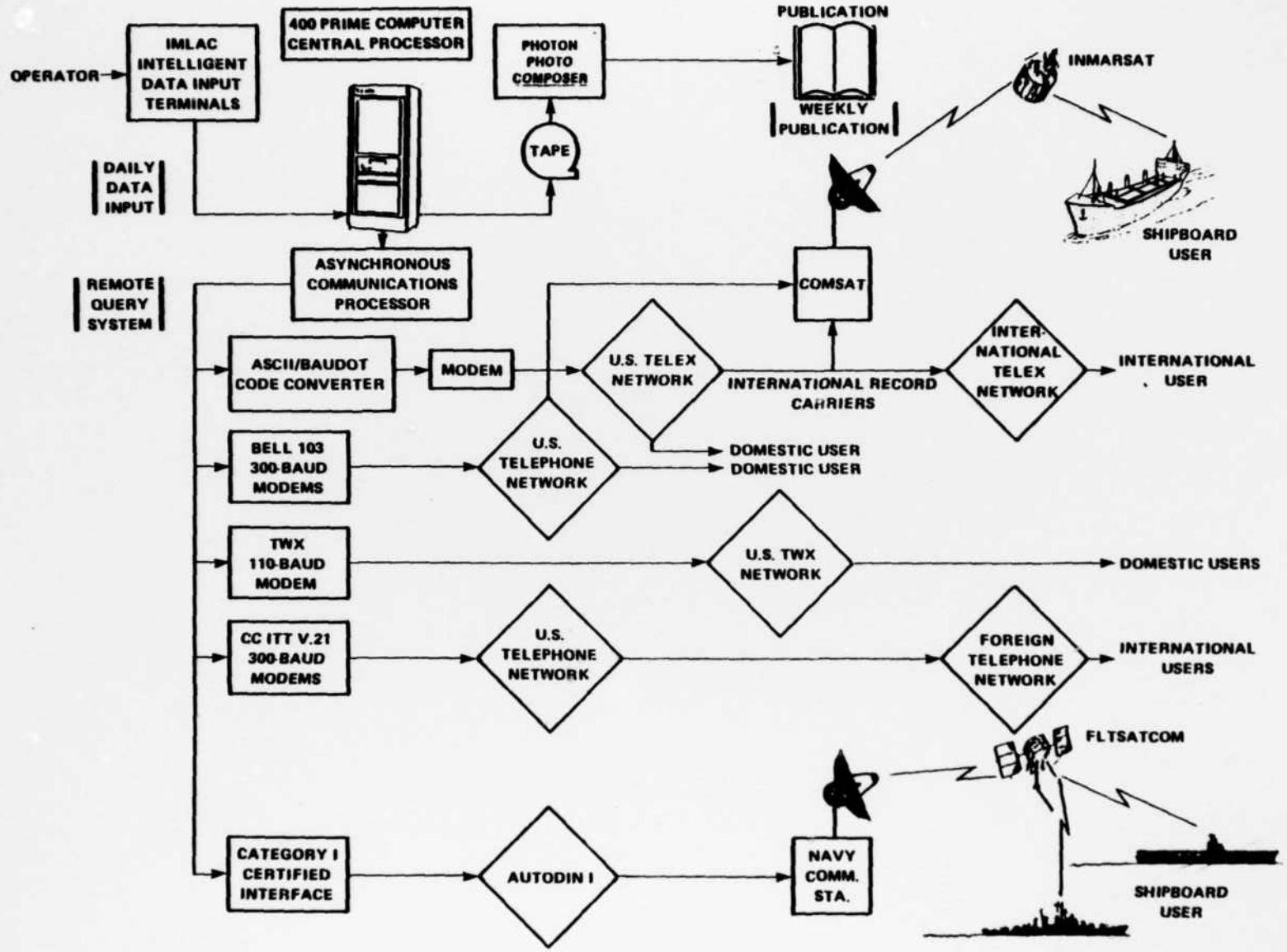

Figure 1.

are shipping companies, U.S. merchant vessels, and U.S. Navy ships. DMA estimated initially that about 600 users would query the data base four times a month from a total population of over 10,000 subscribers to the publication.

Of all potential remote access customers, those at sea would benefit the most from rapid data access. There is an increasing number of mariners with satellite terminals providing access to the ANMS. INMARSAT has grown from 600 participants in August 1981 to over 1200 participants in December 1982; it can support the interactive communications needed for ANMS remote queries. The growth of the INMARSAT population reflects a predictable growth of ANMS remote query customers. Other customers, who have been identified through their specific requests for automated data, are DMA field offices, U.S. Government agencies, and agencies of foreign governments, particularly the Hydrographic Office of the Federal Republic of Germany, which is an active user of the remote query system.

THE AUTOMATED NOTICE TO MARINERS PILOT PROGRAM

Background

The R&D feasibility study indicated that the only telecommunications links that could easily and economically reach ANMS users were networks that were designed for other than computer data transfer, such as voice or teletype. These networks are TWX, Telex, the U.S. domestic telephone network, AUTODIN I, AUTOVON, and overseas public telephone networks. Of the networks identified, only the public telephone network is used to any extent for high-volume data transfer. Since these networks do not primarily transmit data, it was discovered that equipment for interfacing most of them to the ANMS for data transfer was virtually nonexistent, and in fact, most available equipment was not specifically designed for the ANMS application. Therefore, the pilot program had to address techniques to install and custom engineer widespread existing technology to meet the mariners specific needs for receiving navigational information.

The pilot program began with a detailed technical study of the different characteristics and coverage of each candidate network interface system. The study identified the equipment and software needed to build the interfaces. As the effort progressed, equipment was purchased or leased from vendors and linked to the ANMS. Two problems surfaced:

1. Components (modems) did not function according to specifications.

2. Vendors were not familiar with data applications of their systems.

As a result, network characteristics had to be studied to determine what components would properly interface with the network or user terminals.

In addition, during testing of newly installed systems, unanticipated characteristics of the network or user's particular equipment were encountered. This created a need for additional studying, testing, and redesigning of the system or procedures as the pilot program progressed. The solution to one problem sometimes uncovered another problem, thus making the pilot program time consuming. Simple, fast solutions were rare; however, as a result of this effort, DMA now has unique systems specifically designed to bring the ANMS to users without additional equipment or network access expense.

Equipment modifications involved other areas as well as external hardware design. The Prime 400 had to be updated to a higher operating level to make the Telex system operate. Also, output ports had to be reconfigured through both software and hardware adjustments. Unique software was developed to accommodate batch inputs as well as interactive inputs and to hold open communication ports for processing information without logging in.

Public Telephone Network

DMA initially installed five low-speed, full-duplex modems to the DMA central exchange. These modems provide access to the ANMS via AUTOVON, INMARSAT voice circuits, overseas public telephone networks, and the U.S. public networks. The modems operate at 300 words per minute (wpm) and provide a global and highly accessible service to anyone with a relatively inexpensive modem and teletypewriter or a terminal containing both (such as the Texas Instrument Silent 700). The modems use the Bell 103 type analog signaling system, which is standard in the U.S.

Although the telephone network provided access to mariners at sea through INMARSAT satellite voice circuits, the mariner would have to purchase, maintain, and store a portable acoustically coupled terminal in order to receive the ANMS data. There was concern that this might discourage use of the ANMS by mariners. The solution to this problem was to allow the mariner to initially receive ANMS data on the teletype circuits supplied with and installed on the INMARSAT satellite earth station on the ship. Therefore, access was needed to the ANMS through teletypewriter networks.

Western Union TWX Interface

It was decided that the ANMS output should be made compatible with the teletype keyboards and printers already installed on ships. These units operate at 66 2/3 wpm using the five-level Baudot code. The Prime AMLC transmits and receives a seven-level ASCII code at no less than 75 wpm. In order to introduce the ANMS to mariners, DMA elected to install the Western Union TWX network, which operates at Prime compatible codes and speeds and interfaces to Baudot-coded networks through code and speed converting computers that can be accessed by the mariner. This network is interfaced to Western Union TWX, COMSAT teletype, and several International Record Carriers (IRC's) for further connection to overseas teletype networks. By connection to TWX, the needed compatibility was provided by

the network vendors. The TWX network also directly supplies ANMS remote access to many shipping companies.

TWX service was installed using a Bell 103 type modem which has the same technical specifications of the TWX network and interface equipment. Also the Western Union TWX equipment is designed to provide an "answerback" identification code as soon as a call is connected. The Prime could not be modified to automatically send an answerback code, therefore, a separate hardware component was purchased to supply it.

Western Union Telex Interface

The Telex network-to-computer interface had to provide a means for converting the data rates (66 2/3) wpm Telex to 75 wpm or higher from the Prime) and for translating between the ASCII and Baudot codes. Few vendors market ASCII-to-Baudot translators. The unit selected, a TBA 1000, was designed to operate on radio teletype circuits. It was selected, because it was well documented, appeared to be of good quality, and was the most cost-effective solution (Figure 2).

Several modifications were made to the unit including increasing the buffer in the code and speed translator, redesigning the circuitry so that the Prime computer would accept the Telex terminal LOGIN command, and again changing the circuitry to eliminate a problem of erroneously printed numbers and punctuation marks in certain areas of the message text.

Two additional pieces of equipment were installed in the interface. They were wired serially between the computer and the Telex equipment. The Telex Line Adapter (TLA), supplied by Western Union, is a modem that uses direct current (dc) voltages to signal the presence of an incoming call. The answering equipment must also provide a dc output voltage shift to answer the call. An autoanswer unit (NA Data AT6RO) was placed between the TLA and the code translator to provide these functions.

Telex, like TWX, requires an answerback code. In the Telex case, the code is sent only when a "Who are you?" code sequence is received from the remote station. The Baudot sequence for this was the "Figures" code followed by the "D" code. The converter translates this code sequence to a "$" symbol. An answerback unit, Auto Answerback (Blackbox AB-1D), identical to the one used on the TWX circuit was installed between the translator and computer to recognize the "$" and return the answerback code sequence.

Overseas Telephone Network Using International Modem Standard (CCITT V.21)

The Hydrographic Office in Germany requires information from the U.S. Notice to Mariners. To establish service, a modem conforming to the standard specified in Recommendation V.21 of the International Telephone and Telegraph Consultative Committee (CCITT V.21) was installed.

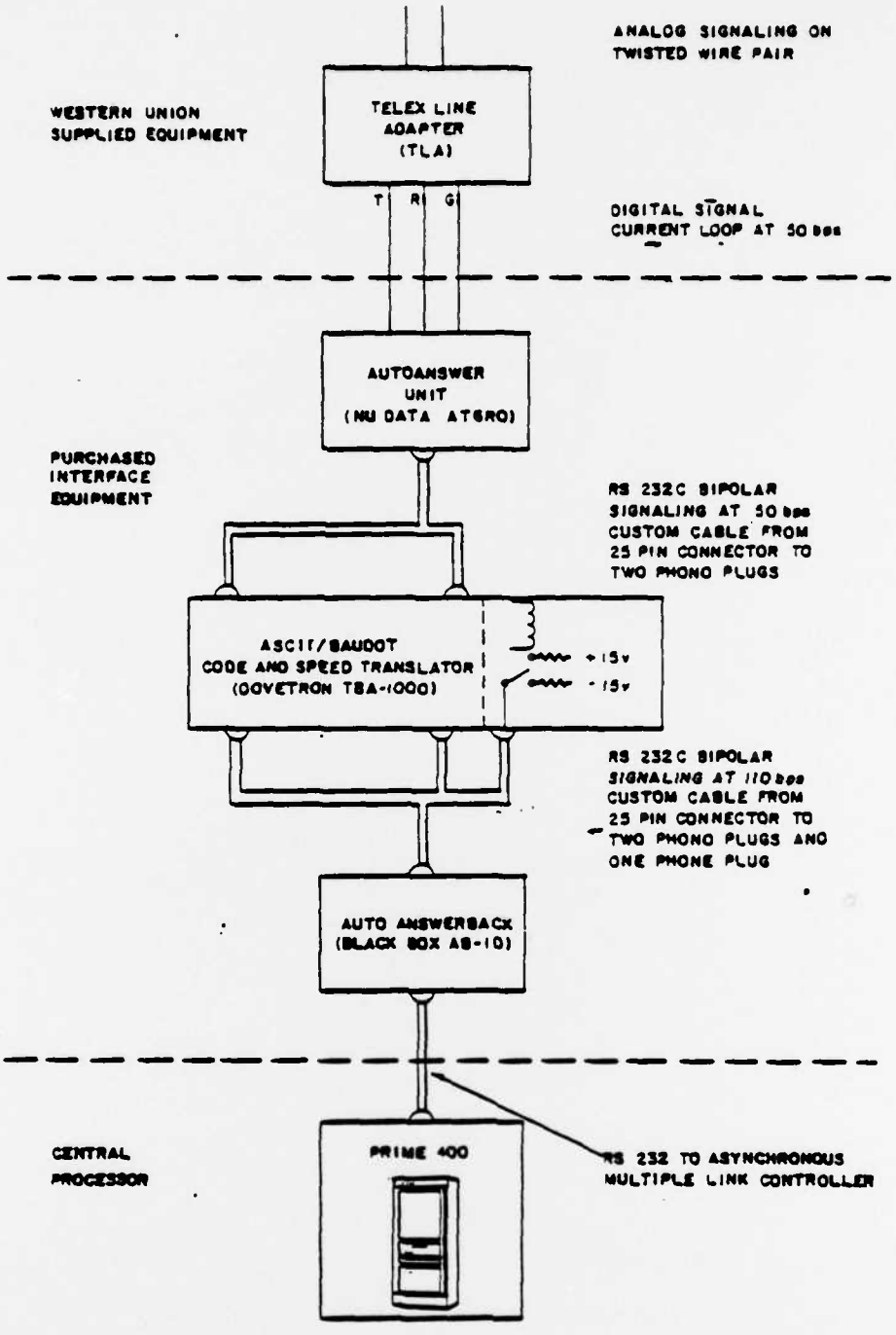

Figure 2. Hardware Configuration for Telex Interface

Operational testing was conducted with Germany to verify system performance. The modems were able to synchronize, but commands sent by the Germans were intermittently rejected by the computer slowing the query/response interchange. The data received was clear, but random characters appeared at the beginning of some lines. The problems were determined to be in the Prime 400 software

and special procedures were established so that initiation of an appropriate series of commands would result in a text free of error.

AUTODIN I Interface

The U.S. Navy is a primary customer for the ANMS. The Navy has its own worldwide communications system consisting of satellites and shore MF and HF radio stations. The most reliable access for the Navy to ships at sea is through FLTSATCOM. This system could be accessed by DMA through the AUTODIN I.

The use of AUTODIN I and FLTSATCOM is restricted and administrative approval is necessary through the Defense Communication Agency (DCA). DCA has indicated that DMA's transmission requirements could be met with AUTODIN I service because messages are small and ANMS traffic volume is low. DCA defined the changes in procedures necessary to link the AUTODIN I with the Navy system. AUTODIN I uses information in the headers for routing, but this would deliver a message only as far as a shore station. Its destination is a ship. The Navy has its own routing system from shore stations to ships at sea.

The AUTODIN I interface is a different and more complex system than the network interfaces already installed. Queries must be run from parameters extracted from a message rather than using the already existing ANMS query routines. Software must be developed to handle the message format and satisfy AUTODIN I category III requirements. To date, work on completing the AUTODIN I link to ANMS has been started, but is not complete.

FUTURE CAPABILITIES

Introduction

The focus of the pilot program is to convert the present developmental system into a mature operational system. A mature system must:

1. Be able to provide data to all users when needed.

2. Provide customers with convenient and affordable access.

3. Provide access that supports varying users needs, such as fast data rates to provide economy for those with small data needs.

4. Be cost efficient for DMA.

5. Preserve the integrity of the data.

INMARSAT is the only communications system that can provide the necessary access for the U.S. Merchant Marine Fleet at sea. Not all ships have INMARSAT terminals and, therefore, cannot be served until they do. All other (land based) users with a comm link to the systems described in this paper can receive the data. Any improvements to the ANMS

system that could be made would improve service over already available networks rather than expanding coverage.

Downstream Loading

Large users of ANMS including the U.S. Coast Guard and Exxon International have expressed a desire to be able to receive by transmission, weekly updates of the ANMS data base. They would prefer to acquire by magnetic tape the total ANMS data base as well as the computer programs designed to manage the data base, then query their own computer system rather than DMAs Prime computer when they required ANMS information.

Therefore, DMA has initiated an R&D project with USAETL to develop a downstream loading capability. The project is to develop a software system that is transportable for cross compilation to a variety of ANMS user computer systems that support COBOL. The project will also design, and if feasible, build a low cost stand alone mini or microprocessor system that could handle by itself interactive queries and telecommunications to users as well as DMA (for weekly updates).

Graphics Transmission

The ANMS is basically a text data base. The Notice to Mariners booklet also contains chartlets. The chartlets are updated sections of nautical charts designated to replace older data. There is a requirement to develop a storage and retrieval capability on the Prime 400 computer for digital chartels. An in-house (ETL/DMA) study is addressing the various aspects of a graphics storage, retrieval, and transmission system.

Value-Added Networks

The R&D feasibility study recommended the use of value-added public data networks such as Telenet or Tymnet for ANMS distribution. These networks could supply service matching almost all the systems presently installed on the ANMS. They do not interface the AUTODIN nor COMSAT directly. Value-added networks can supply both domestic and foreign service through dial-up telephone lines up to 1200 bps and service to other computers or intelligent terminals at speeds from 2400 bps to 56,000 bps. The main advantage to DMA using value-added networks is the very low error rates (1 error in 10^{12} bits). The disadvantage is that the cost is considerably higher than the equivalent coverage using on-site modems. Also, most ANMS users do not subscribe to value-added networks, therefore the user would also incur an additional cost. It is anticipated that value-added networks will be utilized in the future when the cost becomes comparable with present systems.

FUTURE TRENDS

In order for an ANMS user to receive notices via telecommunications, he must be linked to a telecom network which is linked to the ANMS computer. For users at sea, the system must employ a satellite. One of the limiting factors in present systems is that existing satellites may not have enough circuits to handle all future marine

users. Traffic growth forecasts indicate the need for greater capacity. For example, the U.S. Coast Guard will require that all future U.S. ships have INMARSAT terminals. The trend therefore is to replace satellites in present systems with new satellites designed with advanced technology. Also, complete new telecommunication networks will be implemented using higher frequencies. New systems will require new regulations concerning the administration of the frequency spectrum.

While the electromagnetic spectrum and the geosynchronous orbits determine the bounds of satcom ultimate growth, many new techniques have been tested that will expand capacity without excessive demands on satellite mass and power. Among them are use of higher frequency bands, i.e., 11 and 14 GHz, 19 and 29 GHz; use of intersatellite relaying, electrical propulsion for station keeping and positioning; multiple beam antennas; and higher efficiency solar cells. In addition to advances in technology, the European Space Agency is planning a maritime satellite call MAROTS and the U.S. Defense Department is implementing the DSCS III and the Digital Data Network. Within all networks higher line speeds are being developed. For example, Telex is planning to upgrade to 2400 bps (Teletex and Super Telex).

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